EXISTENCE OF RADIATIVELY INDUCED FERMION RESONANCE (RFR) FROM THE STOKES PARAMETERS

ABSTRACT

The classical polarization tensor of light is shown to contain a term proportional to the vector product of the Pauli matrix σ_3 with the conjugate product $A \times A^*$ of complex magnetic vector potentials. This simple analysis confirms the existence of a first order interaction energy:

$$E_n = -i\frac{e^2}{2m}\sigma_3 \cdot \mathrm{A} \times \mathrm{A}^*$$

between classical, circularly polarized radiation, and a fermion or classical charged particle.

INTRODUCTION

The classical polarization tensor of light {1}contains a term that shows the ability of circularly or elliptically polarized radiation to induce fermion resonance, a phenomenon which we have named radiation induced fermion resonance (RFR) {2-5}. The resonance frequency induced in this way is proportional to I/ω^2 where ω is the angular frequency,and I the intensity of the radiation, in units of radians per second and watts per square meter respectively. The theory produces {2-5} electron and proton spin resonance at frequencies approaching the visible range under accessible conditions, thus greatly increasing the instrumental resolution of current magnet based instruments of any kind. The RFR phenomenon can also be used to supplement the permanent magnet {6}, producing in principle a greater instrumental resolution and site specific effects by second order perturbation theory {5}.

THE STOKES PARAMETERS.

Define the four Stokes parameters {6, 7} in terms of the components of the magnetic vector potential:

$$\begin{aligned} S_0 &\equiv A_X A_X^* + A_Y A_Y^* \\ S_1 &\equiv A_X A_X^* - A_Y A_Y^* \\ S_2 &\equiv A_X A_Y^* + A_Y A_X^* \\ S_3 &\equiv -i\left(A_X A_Y^* - A_Y A_X^*\right) \end{aligned} \tag{1}$$

In circularly polarized radiation:

$$S_1 = S_2 = 0 \tag{2}$$

and the general relation:

$$S_o^2 = S_1^2 + S_2^2 + S_3^2 \tag{3}$$

reduces to:

$$S_0 = \pm S_3. \tag{4}$$

Therefore the existence of

$$S_0 \equiv |A \bullet A^*| \tag{5}$$

implies that of

$$S_3 \equiv \mp i |\mathrm{A} \times \mathrm{A}^*| \tag{6}$$

in circularly polarized radiation. The two signs in eqn. (6) denote left and right handed circular polarization respectively.

THE CLASSICAL LIGHT INTENSITY TENSOR.

We can choose to describe the light intensity tensor {6-10} in terms of a complex, rank two, tensor with a symmetric real and anti-symmetric imaginary part:

$$I_{ij1} \propto \begin{bmatrix} A_X A_X^* & A_X A_Y^* \\ A_Y A_X^* & A_Y A_Y^* \end{bmatrix} \tag{7}$$

or as a real valued Stokes matrix:

$$I_{ij2} \propto \begin{bmatrix} A_X A_X^* & -iA_X A_Y^* \\ -iA_Y A_X^* & A_Y A_Y^* \end{bmatrix}. \tag{8}$$

In both cases, the tensor can be expressed in terms of the Stokes parameters, respectively:

$$I_{ij1} \propto \frac{1}{2} \begin{bmatrix} S_0 + S_1 & S_2 + iS_3 \\ S_2 - iS_3 & S_0 - S_1 \end{bmatrix} \tag{9}$$

and

$$I_{ij2} \propto \frac{1}{2} \begin{bmatrix} S_0 + S_1 & S_3 - iS_2 \\ -S_3 - iS_2 & S_0 - S_1 \end{bmatrix} \tag{10}$$

These matrices can be expressed as combinations of Pauli matrices as follows. Resonance can be induced between the states of the appropriate Pauli matrix as usual.

THE PAULI MATRICES

There are several representations possible for the Pauli matrices, as discussed for example by Sakurai {11}, they are defined by the SU(2) group symmetry in any situation in dynamics and electrodynamics. Therefore we express the real and physical Stokes matrix (10) as a linear combination of the Pauli matrices:

$$\sigma_0 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}; \quad \sigma_1 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}; \quad \sigma_2 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}; \quad \sigma_3 = \begin{bmatrix} 0 & i \\ -i & 0 \end{bmatrix}; \tag{11}$$

which form the SU(2) relation:

$$\left[\frac{\sigma_1}{2}, \frac{\sigma_2}{2}\right] = -i\frac{\sigma_3}{2} \text{ et cyclicum.} \tag{12}$$

For circularly polarized radiation, the Stokes matrix is the real valued sum of two Pauli matrices:

$$I_{ij2} \propto \frac{1}{2}\begin{bmatrix} S_0 & S_3 \\ -S_3 & S_0 \end{bmatrix} = \frac{1}{2}\left(S_0\sigma_0 - iS_3\sigma_3\right) \tag{13}$$

and it is clear that resonance can be induced between the states of the real valued matrix $-i\sigma_3 = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$.

DISCUSSION.

The energy of interaction between a classical charged particle and the classical Stokes matrix (13) is dimensionally proportional to:

$$En \propto \frac{e^2}{2m} A^{(0)2}\left(\sigma_0 - i\sigma_3\right) \tag{14}$$

where e/m is the charge to mass ratio of the particle. Assuming that the constant of proportionality is unity, we arrive at the same result as derived in a number of different ways in ref. (3) from the minimal prescription. For an electron, and in S.I. units, the expected resonance frequency is {3, 4}:

$$\omega_{res} = 1.007 \times 10^{28} \frac{I}{\omega^2} \tag{15}$$

and appears in the far infrared to visible region under accessible conditions {3, 4}.

In summary, we have derived the phenomenon of radiatively induced fermion resonance in the simplest possible way, by re-expressing the Stokes matrix in term of a sum of two Pauli matrices, Other derivations of the same result are given in ref. (3).

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